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THE EXPLOITATION AND MANAGEMENT OF GEOTHERMAL RESOURCES IN XI`AN

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Abstract

XI`AN is a famous cultural city with a long recorded history, and it has rich geothermal resources. The exploited resource quantity is estimated to be of the order of 5.31 x 108 M3. The resource is mainly used for earthquake observation, space warming, bathing, physiotherapy, flower growing, fish farming, agriculture cultivation, and peace and happiness tours. DongDa Cultivation Center has the largest geothermal cultivating fields in the world.

In order to make the limited resources produce the greatest profit, it is necessary for it to be reasonably exploited and managed scientifically. The management methods adopted at XI`AN are:-

Making laws - these laws set out the management rules by which the resource will be used

Resource Plan - based on sound scientific knowledge of the resource which enables wells to be located scientifically.

Management - integrated planning, examination and use approval process

Organizing of specialist groups. -These include; geothermal specialist group who give advice on best location and production depth of the wells; supervisors group who organize the construction of the wells; and a dynamic monitoring group who monitor well production characteristics and resource water levels.

These management methods enable the resource to be exploited in a legal, scientific, sustainable and efficient manner

At present, technical problems relating to the recharge of the resource by cool surface water which are causing geothermal cooling are being studied.

1 Introduction

XI`AN is located in the middle part of the Weihe River basin in the south part of Fen-Wei basin. The geology consists of sandy mudstone and mudstone conglomerate in Neogene system, they have good water bearing characteristic which form good thermal reservoirs, overlying the resource there is a mudstone caprock which provides good thermal insulation and pressure containment of the resource.

The area has a number of faults; the main ones being the East to West striking Weihe fault, and the Chang`an - Lintong deep mega fault and the South to North striking ChanHe fault, Feng He fault, and Jing He faults which intersect at nearby XI`AN. These faults provide good transportation and migration routes for the geothermal fluid. The general data shows that recoverable reserves of C + D + E grades is around 5.31 x 10^8 M^3 in the geothermal fields around XI`AN city which occupy an area of 466 square kilometers. More than twenty different kinds of micro elements have been found in the geothermal water

and the water has good medical treatment value. The XI~AN geothermal resource has good economic and social benefit uses.

2 Exploitation and Usage Condition of XI`AN Geothermal Resource

There is a long history to the exploitation and use of the geothermal resources in XI`AN. The famous Tang Dynasty poet JuYI Bai wrote in one of his poems " *bathing in Hua Qing Chi in cold Spring, Warm water is suitable to clean up grease".* A large number of mid to low temperature water wells were drilled along the mountain foreground zone in LanTian county and Chang`an county from 1970 to the middle of the 1980`s. It was not until 1988, however, that geothermal wells were drilled within the boundary of XI`AN city. This drilling was undertaken with the support of the city government and carried out by the Administrative Bureau of Mineral Resources. Today there are 110 wells within the city boundary with 63 of the wells located within the city proper. The well head outlet temperature of the geothermal fluid averages around 65 ^{0}C, with the maximum well having an outlet temperature of 102 ^{0} C. The largest production flow from an XI~AN well is 223.4 cubic meter's per hour. The total production quantity in 1998 was 19 million cubic meter's.

2.1 The Development of Bathing and Physiotherapy Programs

Bathing is the current and foreseen long term main use of geothermal hot water in XI`AN city. Service items include; common bath, pool bath, solo bath, lashing wave bath, and vapor baths. The previous lack of these municipality services, due to a poor water supply, has now been solved by the use of the warm geothermal water. The city profit from the geothermal bathing water is up one million yaun per year.

For many years one workers hospital has made use of Xue and Zhu geothermal water to cure diseases. This 2000 square meter facility has 53 hospital beds. Medical records show that the bathing in the hot mineralized geothermal waters has a good curative effect on skin diseases, arthritis, and heart/blood vessel disease. The profit for one year is between 1.2 million yuan.

2.2 The Development of Space Warming Projects

These type of projects have developed rapidly since 1996, when the Administrative Bureau of Mineral Resources advocated and encouraged the use of geothermal hot water for space heating purposes. Currently there are eleven organizations using this form of heating. The total area of buildings being supplied with geothermal space heating is around 5 million square meters.. There are two ways of supplying the space heating: by direct use and indirect use. The fossil fuel saved each year has been estimated to be around 28.5 thousand tons of coal which has a value of around 0.7 million yuan.

2.3 The Development of Cultivating Projects

Plans have been made for geothermal hot water to be used in horticulture, fish farming and hot spring vacation villages to be set up alternatively along the Weihe river zone of the northern suburb of XI`AN city. Many organizations have been asking for such developments to be undertaken this year, however, these projects are still at the planning stage.

Large scale fish farming with geothermal water is carried out in Chang`an county where the Dongda cultivating fish ponds occupy an area of around 270 acres. This is possibly the largest cultivating fish pond area in Asia or in the world. Initially tropic infant fish spend winter in nursery pond near XI`AN and are then transferred when mature enough to the larger cultivating ponds.

Currently only one organization raises fish in geothermal heated ponds in the northern suburb of XI`AN city. The cultivated area of the fish farm is around 2 acres. This is an experimental undertaking which has so far raised more than 300 thousand luofei fish.

The Cuibao organization cultivates flowers and plants in geothermal heated greenhouses. They have a cultivating area of 133,400 square meters and raise 160 varieties of plants which provides them with a good financial return.

2.4 The Development of Improving Health Projects

At present there are, two standard indoor swimming halls, one standard indoor diving/ swimming hall, eight non-standard indoor swimming halls located within the XI`AN city and in the surrounding communities there are a further eight non standard swimming halls all heated with geothermal water. These facilities have been completed since 1995. People can swim in all seasons, and this meets peoples demands of improving health and enjoying their spare time.

2.5 The Appearance of Hot Spring Vacation Villages.

Dangda vacation village in Chang`an county is based around hot geothermal spring. This has resulted in the development of many service trades to provide for the vacationing tourists. Pear Garden village and Weishuiyuan vacation villages located in the northern suburbs of XI`AN city depend on geothermal hot spring water for their popularity. Here the visitor can enjoy leisure bathing sports and distinctive flavored food businesses. They attract many city people. The guest room turn over ratios are much more than other hotels located within the city.

2.6 Earthquake Observation and Measurement

At present there are two wells used for observing and measuring earthquake events in XI`AN. One of these wells has been used since 1971, but the obvious relation in earthquakes Grade 4 and lower with geothermal well headwater level was not discovered. The relation of earthquakes above the grade 4 level with headwater level has not been affirmed because earthquakes at this level do not occur very frequently in XI`AN.

3 The Management Characteristics of Geothermal Resources in XI`AN.

As the administrative organization of geothermal resources of the XI`AN city government, with the assistance of other organizations and the cooperation of exploiting and using organizations, the Administrative Bureau of Mineral Resources is setting a management method which is suitable for the step by step development of the valuable natural geothermal resources of the area.

3.1 The Management Method

The management methods adopted at XI`AN are:-

Making laws - these laws set out the management rules by which the resource will be used

Resource Plan - based on sound scientific knowledge of the resource which enables wells to be located scientifically.

Management-integrated planning, examination and use approval process

Organizing of specialist groups. -These include geothermal specialist group who give advice on best location and production depth of the wells; supervisors group who organize the construction of the wells in order to guarantee the construction quality of every well; and a dynamic monitoring group who monitor well production characteristics and resource water levels.

These management methods enable the resource to be exploited in a legal, scientific, sustainable and efficient manner

3.2 Work Undertaken within Management Method

The examination and approval procedure for drilling geothermal wells is very strict and organizations which seek permission to drill such wells must pass the feasibility proof report and the specialists appraisal of the feasibility report. According to the specialists opinion, the Administrative Bureau of Mineral Resources asks the city government for approval to drill the well.

The well head master valve must now conform with an approved standard. The corrosion caused by geothermal water is a serious problem due to the gas and corrosive elements it contains which reduces the service life span of the well. The corrosion problem is now controlled by adopting a new seal technology to the well heads. For example, prior to introducing the new seal technology the well pipe of the Huashan hospital wells suffered corrosion rates of over 0.5mm per year after adoption of new seal technology the corrosion phenomenon has not appeared.

The Administrative Bureau insist that the rules governing the sealing of well heads are complied with and stipulates the flow measuring and their setting for each well. Most organizations that supply warm geothermal water use corrosion resistant electric driven pumps with adjustable speed control devices, ability to remove sand from the apparatus and the use or rubber seals to connect to the well outlet pipe.. Indoor temperatures can be automatically regulated by a flow control valve according to the climatic change, indoor temperature desired and a time signal for initiating the space warming.

Management and the monitoring of geothermal water usage are strongly supported. Water use targets are adjusted according to the water position within the wells and ever user is required to practice conservative use of the resource Each geothermal reservoir are individually controlled with the exploitation and protection of the resource being monitored by the way of quarterly target checks and a final end of year check. The system rewards saving achievements and punishes over mining. Draw down of the individual reservoirs are monitored by measuring the water level in the wells and comparing the results with planned principles.

4 Defects in the Exploitation and Management of the Xue and Zhu Geothermal Resources

At present the output from most geothermal wells are only used for bathing and the present method of exploiting the resource does not result in the most comprehensive and efficient use of the resource.. Multi use and comprehensive use of the resource is low. The discharge temperature of most of the uses is high and this causes much resource waste.

Well outlet flows are not properly controlled and manual self control is low. Most of the organizations that drilled wells before 1997 made use of conventional water lift machines and used simple self made well head isolating valves which leak and cause major corrosion problems.

5 Plan for Work in the Future

5.1 Better Matching of Uses with the Available Resources in the Different Regions

Different management policies will be carried out which will ensure a comprehensive usage plan is prepared to match the availability of the geothermal resources in the different regions.

5.2 Geothermal Resource Management Data Bank to be Set Up

All geothermal well data to be recorded in a central scientifically managed data bank. The data of exploitation usage and work condition of every well will be collected and catalogued.. The dynamic condition of geothermal water position in every well will be recorded at periodical intervals and studied. Automating and computerization the data collection and management will be put into practice as soon as possible.

5.3 Establishment of a Sound Long Term Survey System

Long term measurement technology will become a normal practice and from which sound records will be derived on which to base more exact resource evaluations.

5.4 Computerized Automatic Control of Space Heating Geothermal Water Flows

Day to day management of space heating systems geothermal hot water flows to be adjusted according to need requirements by a computerized control system.

5.5 To Improve Geothermal Comprehensive Usage Technology

Investigations will be carried out into comprehensive methods of making more efficient use of the available geothermal resources. Test projects will be set up an the Xue and Zhu geothermal fields to demonstrate comprehensive resource use methods.

5.6 To Improve Geothermal Well Head Devices

All old well head devices will be progressively replaced with approved equipment.

5.7 Research into Geothermal Injection, Recharge and Cooling

Work currently being undertaken in these areas will be continued.

5.8 Research into Geothermal Fluid Corrosion Problems

Work currently being carried out in this area will be continued

5.9 Measuring and Studying the Influence of Geothermal Exploitation and its Effect on Geological and Ecological Environments

Work currently being carried out in these areas will be continued.

Overseas assistance to cooperate in the development of the geothermal resources in XI`AN will be welcomed. Also welcomed would be the assistance of foreign specialists in

geothermal research into usage and efficient exploitation of the XI`AN geothermal resources.
